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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/800,695	03/16/2004	Yi-Nan Chen	4392-0155P	1772
2292	7590	11/16/2004	EXAMINER	
BIRCH STEWART KOLASCH & BIRCH PO BOX 747 FALLS CHURCH, VA 22040-0747			PHAM, THANHHA S	
			ART UNIT	PAPER NUMBER
			2813	

DATE MAILED: 11/16/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/800,695

Applicant(s)

CHEN ET AL.

Examiner

Thanhha Pham

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 13 August 2004.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-16 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-16 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 16 March 2004 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All b) ☐ Some * c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date 08/13/04.
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____.

DETAILED ACTION

Oath/Declaration

1. Oath/Declaration filed on 03/16/04 has been considered.

Claim Objections

2. **Claims 7-9 and 15 are objected to because of informalities. Appropriate corrections are required to clarify the scope of the claim.**
 - With respect to claims 7 and 15, line 1's, typographical error "said step of forming said barrier layer" should be changed to "said step of forming said barrier spacer" (see specification text paragraph [0017] for details).
 - With respect to claim 8, line 3, "when" should be changed to "wherein" to clarify the scope of the claim.
 - With respect to claim 9, line 1, typographical error "The method of claim 1" should be changed to "The method of claim 7" to clarify the scope of the claim (see claim 7 that recites limitation of "forming a conformal barrier layer" for details).

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the

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applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

3. Claims 1-5, 7 and 10-13 are rejected under 35 U.S.C. 102(e) as being anticipated by Honeycutt [US 6,617,689].

➤ With respect to claim 1, Honeycutt (figures 1-3 and cols. 1-10) discloses the claimed method for forming an aluminum-containing interconnect structure comprising:

providing a substrate (12, figure 2, col. 5 lines 17-34 & 51-57) having a contact region (contact plug 15);

forming a first barrier layer (19, figure 2, col. 5 lines 38-40) on said substrate (12);

forming an aluminum-containing conductive layer (20, figure 2, col. 5 lines 40-41) on said first barrier layer (19);

forming a second barrier layer (22, figure 2, col. 5 lines 37-38 and col. 7 lines 8-19);

patterning said second barrier layer (22, figure 2, col. 2 lines 43-44 and col. 3 lines 55-65), said aluminum-containing conductive layer (20) and said first barrier layer (19) to form an aluminum containing interconnection (27) coupling said contact region (contact plug 15) and exposing a sidewall (col. 3 lines 63-65); and

forming a barrier spacer (28, figures 2-3, col. 5 lines 40-44 & 58-62 and col. 7 lines 52-65) on said sidewall of said aluminum-containing interconnect.

➤ With respect to claim 10, Honeycutt (figures 1-3 and cols. 1-10) discloses the claimed method for forming an aluminum-containing interconnect structure comprising:

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providing a substrate (12, figure 2, col. 5 lines 17-34 & 51-57) having a contact region (contact plug 15);

forming a first barrier layer (19, figure 2, col. 5 lines 38-40) on said substrate (12);

forming an aluminum-containing conductive layer (20, figure 2, col. 5 lines 40-41) on said first barrier layer (19);

forming a second barrier layer (22, figure 2, col. 5 lines 37-38 and col. 7 lines 8-19);

patterning said second barrier layer (22, figure 2, col. 2 lines 43-44 and col. 3 lines 55-65), said aluminum-containing conductive layer (20) and said first barrier layer (19) to form an aluminum containing interconnection (27) coupling said contact region (contact plug 15) and exposing a sidewall (col. 3 lines 63-65); and

forming a barrier spacer (28, figures 2-3, col. 5 lines 40-44 & 58-62 col. 7 lines 52-65) selected from a group consisting of titanium, titanium nitride and the combination thereof (col. 5 line 44) on said sidewall of said aluminum-containing interconnect.

➤ With respect to claim 2, Honeycutt (figure 2, col. 5 lines 51-57) discloses said contact region comprises a via contact region (contact plug 15).

➤ With respect to claims 3 and 11, Honeycutt (col. 5 lines 40-41 and col. 7 lines 46-49) discloses said aluminum-containing conductive layer (20) is selected from a group consisting of an aluminum layer, and aluminum alloy layer and the combination thereof.

➤ With respect to claims 4 and 12, Honeycutt (col. 5 lines 38-40) discloses the first barrier layer (19, titanium) comprises using a material selected from a group consisting of titanium, titanium nitride and the combination thereof to form said first barrier layer.

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- With respect to claims 5 and 13, Honeycutt (col. 5 lines 37-38 and col. 7 lines 8-19) discloses said second barrier layer (22, titanium nitride) comprises using a material selected from a group consisting of titanium, titanium nitride and the combination thereof to form said second barrier layer.
- With respect to claim 7, Honeycutt (figures 2-3, col. 5 lines 41-65) discloses said step of forming said barrier spacer (28) comprises: forming a conformal barrier layer (26, titanium or titanium nitride, col. 5 line 44) selected from a group consisting of titanium, titanium nitride and the combination thereof on said aluminum-containing interconnect (27) and said substrate (12); and anisotropic etching said conformal barrier layer (col. 5 lines 58-62).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. Claims 6 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Honeycutt [US 6,617,689] in view of Ashihara et al. [US 6,764,945].

With respect to claims 6 and 14, Honeycutt substantially discloses the claimed method including forming said aluminum-containing interconnect (27) by patterning said second barrier layer (22), said aluminum-containing conductive layer (20) and said first barrier layer (19). Honeycutt does not specifically show in written disclosure that

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forming said aluminum-containing interconnect comprises: forming a patterned photoresist layer on said second barrier layer, said patterned photoresist layer defining said aluminum-containing interconnect; etching said second barrier layer, said aluminum-containing conductive layer and said first barrier layer using said patterned photoresist as a mask; and removing said patterned photoresist layer.

However, combination of such claimed steps for forming said aluminum-containing interconnect is a known technique of patterning using photolithography. See Ashihara et al. as an evidence. Ashihara et al. (figures 9-11, col. 8 lines 59-67 and col. 9 lines 1-17) teaches forming the aluminum-containing interconnect (M1) comprises: forming the patterned photoresist layer (R1, figure 9) on the second barrier layer (23), said patterned photoresist layer defining the aluminum-containing interconnect (col. 9 lines 3-7); etching the second barrier layer (23), the aluminum-containing conductive layer (22) and the first barrier layer (21) using the patterned photoresist as the mask (figures 9-10, col. 9 lines 8-12); and removing the patterned photoresist layer (figure 11, col. 9 lines 14-16).

Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process of Honeycutt by using the known technique of patterning with steps as being claimed, per taught by Ashihara et al, in order to define appropriate conductive path in semiconductor device for interconnection.

5. Claims 9 and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Honeycutt [US 6,617,689] in view of Liu et al. [US 6,099,701].

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> With respect to claim 9, Honeycutt substantially discloses the claimed method including forming said conformal barrier layer to form said barrier spacer. Honeycutt does not expressly teach that forming said conformal barrier layer comprises forming a titanium rich titanium nitride layer having an atom ratio of titanium to nitrogen larger than 1 ($Ti/N > 1$). Generally, Honeycutt suggests forming said conformal barrier (26, figure 2, col. 5 line 44) comprising titanium nitride for barrier spacer (28, figure 3) to prevent void formation caused by electromigration in aluminum-containing interconnect (col. 7 lines 52-65, col. 1 lines 54-67 and col. 2 lines 1-63). Honeycutt also teaches that said barrier spacer functions in the same way as said first and second barrier layers respectively formed under and over aluminum-containing conductive layer for protecting said aluminum-containing interconnect from electromigration (see col. 8 lines 10-36).

However, Liu et al. (col. 1 lines 62-65, col. 2 lines 4-5 & 15-18, col. 4 lines 23-24, and col. 5 lines 30-32) teaches using the titanium rich titanium nitride layer having an atom ratio of titanium to nitrogen larger than 1 ($Ti/N > 1$) as an improved barrier material to reduce electromigration problem -- since titanium-rich titanium nitride adjacent to the aluminum-containing layer would react to form $TiAl_3$ for increasing electromigration resistance.

Therefore, at the time of invention, it would have been obvious for those skilled in the art to combine the teaching of Liu et al. to the process of Honeycutt to form said titanium rich titanium nitride layer having the atom ratio of titanium to nitrogen larger than 1 for said barrier spacer. By doing so, a better barrier spacer will be provided with

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improved ability for preventing void formation and increasing electromigration resistance in the aluminum-containing interconnect (see Liu et al. col. 2 lines 4-5 & 15-18).

➤ With respect to claim 16, Honeycutt substantially discloses the claimed method including forming said barrier spacer selected from a group consisting of titanium, titanium nitride and the combination thereof on said sidewall of said aluminum-containing interconnect. Honeycutt does not expressly teach forming said barrier spacer comprises forming a titanium rich titanium nitride spacer having an atom ratio of titanium to nitrogen larger than 1 ($Ti/N > 1$). Honeycutt only teaches forming said barrier spacer (28, figure 3) to prevent void formation caused by electromigration in aluminum-containing interconnect (col. 7 lines 52-65, col. 1 lines 54-67 and col. 2 lines 1-63).

However, Liu et al. (col. 1 lines 62-65, col. 2 lines 4-5 & 15-18, col. 4 lines 23-24 and col. 5 lines 30-32) teaches using said titanium rich titanium nitride having atom ratio of titanium to nitrogen larger than 1 as an improved barrier material to reduce electromigration problem in aluminum-containing interconnect.

Therefore, at the time of invention, it would have been obvious for those skilled in the art to combine the teaching of Liu et al. to the process of Honeycutt to form the titanium rich titanium nitride spacer having the atom ratio of titanium to nitrogen larger than 1 for improving electromigration resistance in the aluminum-containing interconnect. By doing so, the void formation caused by electromigration can be prevented to improve reliability performance of aluminum-containing interconnection.

6. Claims 8 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Honeycutt [US 6,617,689] in view of Dawson [US 6,677,647].

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Honeycutt substantially discloses the claimed method including forming said barrier spacer (28, figure 3) by: forming conformal barrier layer (26, figure 2, col.5 lines 41-44) on said aluminum-containing interconnect on said substrate; and anisotropically etching the conformal barrier layer (col. 5 lines 58-62).

Honeycutt does not specifically disclose forming said conformal barrier layer by forming a conformal titanium/titanium nitride layer having a thickness of about 300 Å wherein when said titanium layer has a thickness in a range from 0 to 300 Å, said titanium nitride layer has a thickness in a range from 0 to 300 Å.

However, Dawson discloses that the barrier spacer can be formed of a single layer (titanium) or double layer (titanium/titanium nitride) (col. 4 lines 22-33).

Therefore, at the time of invention, it would have been obvious for those skilled in the art to select either single layer (titanium) or double layer (titanium/titanium nitride) for the barrier spacer of the Honeycutt because as taught by Dawson, such single or double material are equivalence for their use in the semiconductor art as the barrier spacer to prevent grain boundary movement and growth which improve the electromigration characteristics of the patterned metal features (See Dawson, col. 3, lines 35-42). Moreover, selection of a known material based on its suitability for its intended use supported a prima facie obviousness determination in *Sinclair & Carroll Co., Inc. v. Interchemical Corp.*, 325 U.S. 327, 65 USPQ 297 (1945).

Dawson also discloses that the titanium layer has a thickness of about 10 to 350 Å and the titanium nitride layer has a thickness of about 50 to 1000 Å (col. 4 lines 23-31). The titanium/titanium nitride barrier spacer of Dawson has the thickness range

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over lap with the thickness range of the invention as claimed. Dawson also discloses that the thickness of conductive sidewall spacers 212 may vary depending upon the particular material and methodology employed (col. 4 lines 18-21).

Therefore, at the time of invention, it would have been obvious for those skilled in the art to form the barrier spacer thickness of Honeycutt in the range as claimed because the thickness range of the barrier spacer can be varied depending upon the particular material and methodology employed, as taught by Dawson (See Dawson, col. 4 lines 18-21). Moreover, the thickness range would have been obvious to an ordinary artisan practicing the invention because, absent evidence of disclosure of criticality for the range giving unexpected results, it is not inventive to discover optimal or workable ranges by routine experimentation. In re Aller, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955). Furthermore, the specification contains no disclosure of either the critical nature of the claimed dimensions of any unexpected results arising therefrom. Where patentability is aid to be based upon particular chosen dimensions or upon another variable recited in a claim, the Applicant must show that the chosen dimensions are critical. See In re Woodruff, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thanhha Pham whose telephone number is (571) 272-1696. The examiner can normally be reached on Monday and Thursday 9:00AM - 9:30PM.

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead can be reached on (571) 272-1702. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

A handwritten signature in black ink, appearing to read 'Thanhha Pham', with a stylized, looped design.

Thanhha Pham
Patent Examiner
Patent Examining Group 2800